Grant agreement ID:
101017536

CERN, Geneva

EOSC-Future ESCAPE Science Projects progress meeting

Progress Report: Wavefier For Multi-Messenger Astronomy

Alberto Iess

EOSC Future

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WAVEFIER: PHILOSOPHY

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WAVEFIER aims to set up a framework for analysis of different types of astrophysical data, paving the way to real-time Multi-Messenger astronomy studies. This is done leveraging the newest available software technologies.

KEY POINTS

- Setup a prototype for a **real time** pipeline for the detection of transient signals and their **automatic** classification.
- Best practice for **software management.**
- Software architecture solutions to prototype a **scalable** pipeline for **big data** analysis in GW context.
- **Interoperability** and access to data and services.
- **ICT services** supporting research infrastructures.
- Use of **data in network** infrastructures and service.

IN COLLABORATION WITH:

WAVEFIER: GOAL

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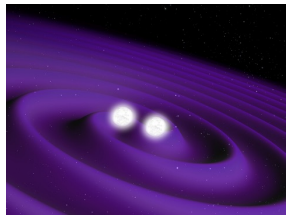
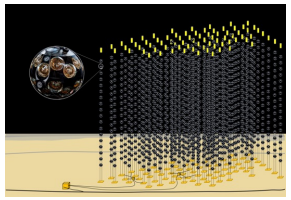
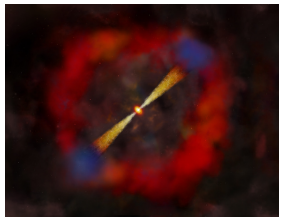
Multi-Messenger Astronomy!







DATA

Gravitational Wave

Neutrino

GRB

stream

WAVEFIER

ML ANALYSIS

attach

PIPELINES

(e.g. WDF for GW data)

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WAVEFIER: CURRENT ARCHITECTURE (tuned for GW data)

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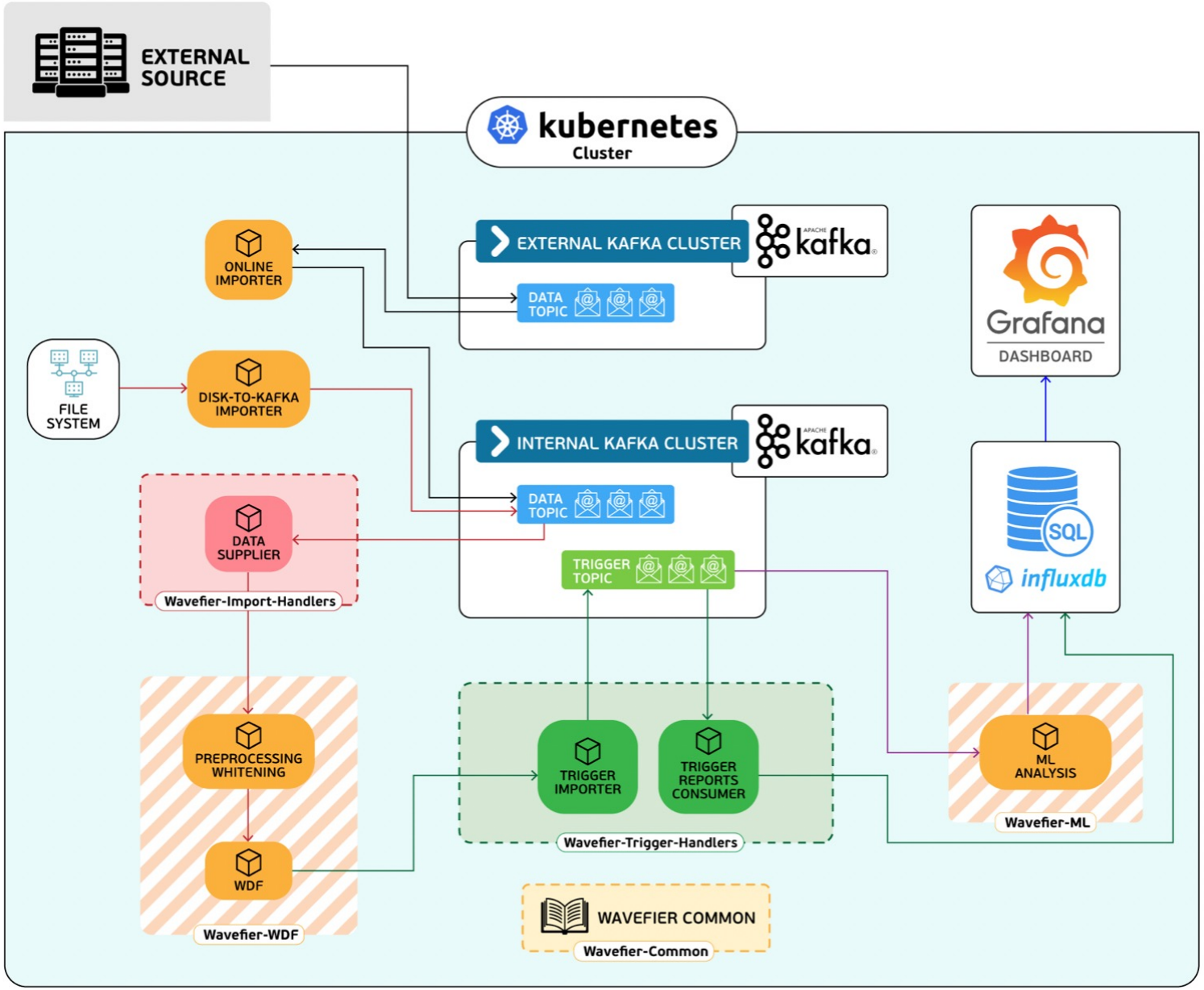

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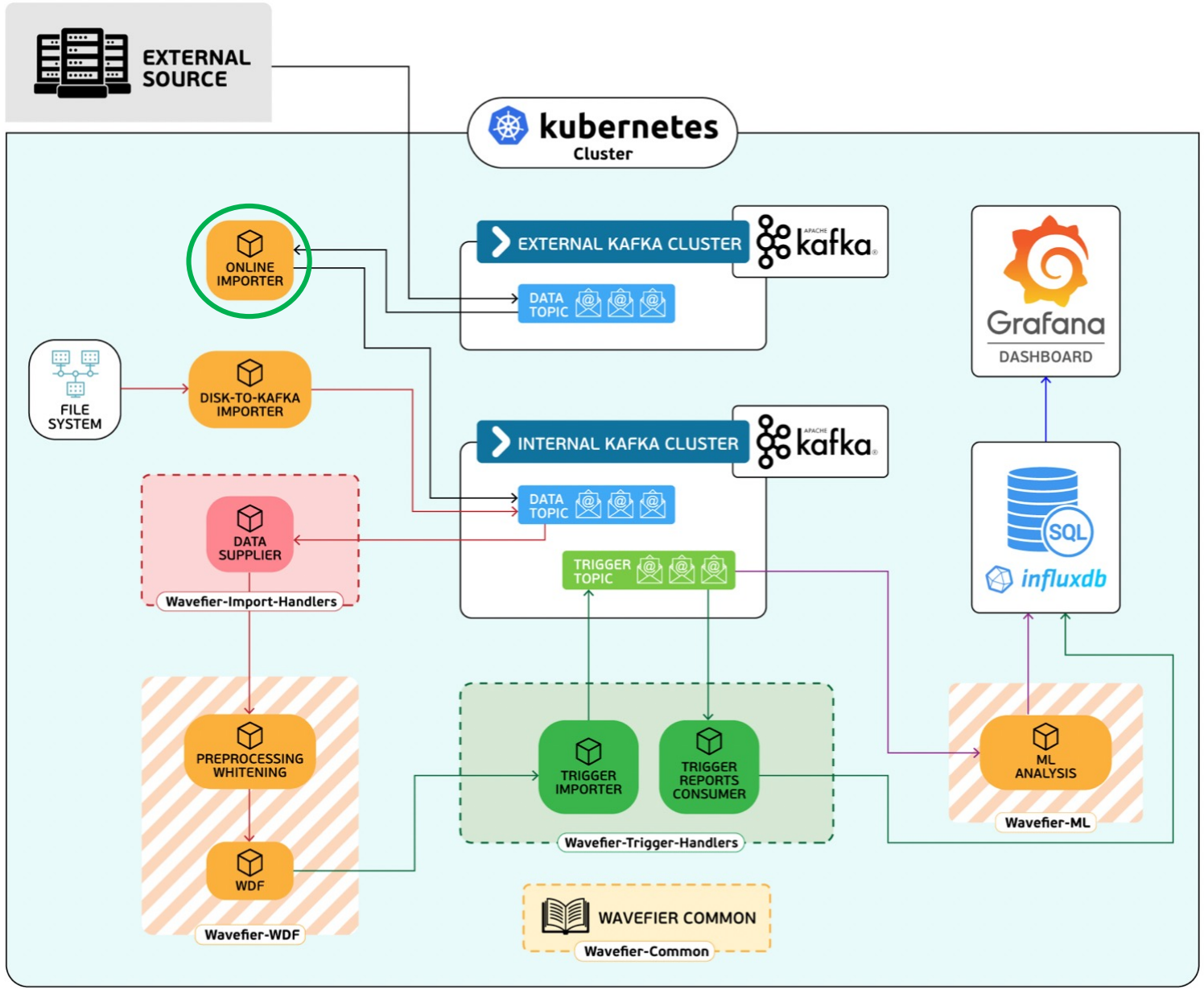
ONLINE IMPORTER

Imports data within
the WAVEFIER pipeline from
external KAFKA cluster.



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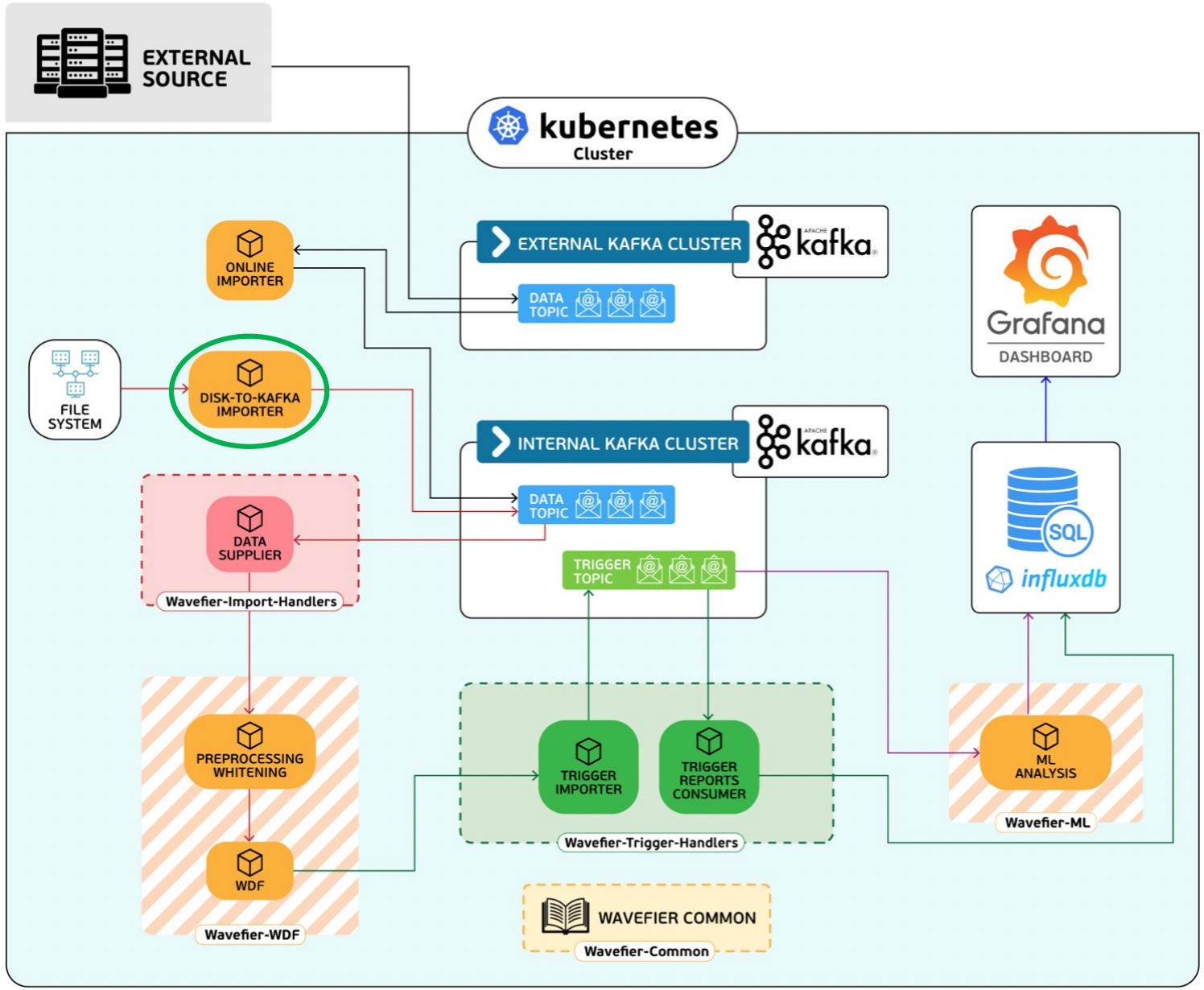
DISK-TO-KAFKA IMPORTER

Imports files within the WAVEFIER pipeline reading from filesystem files.



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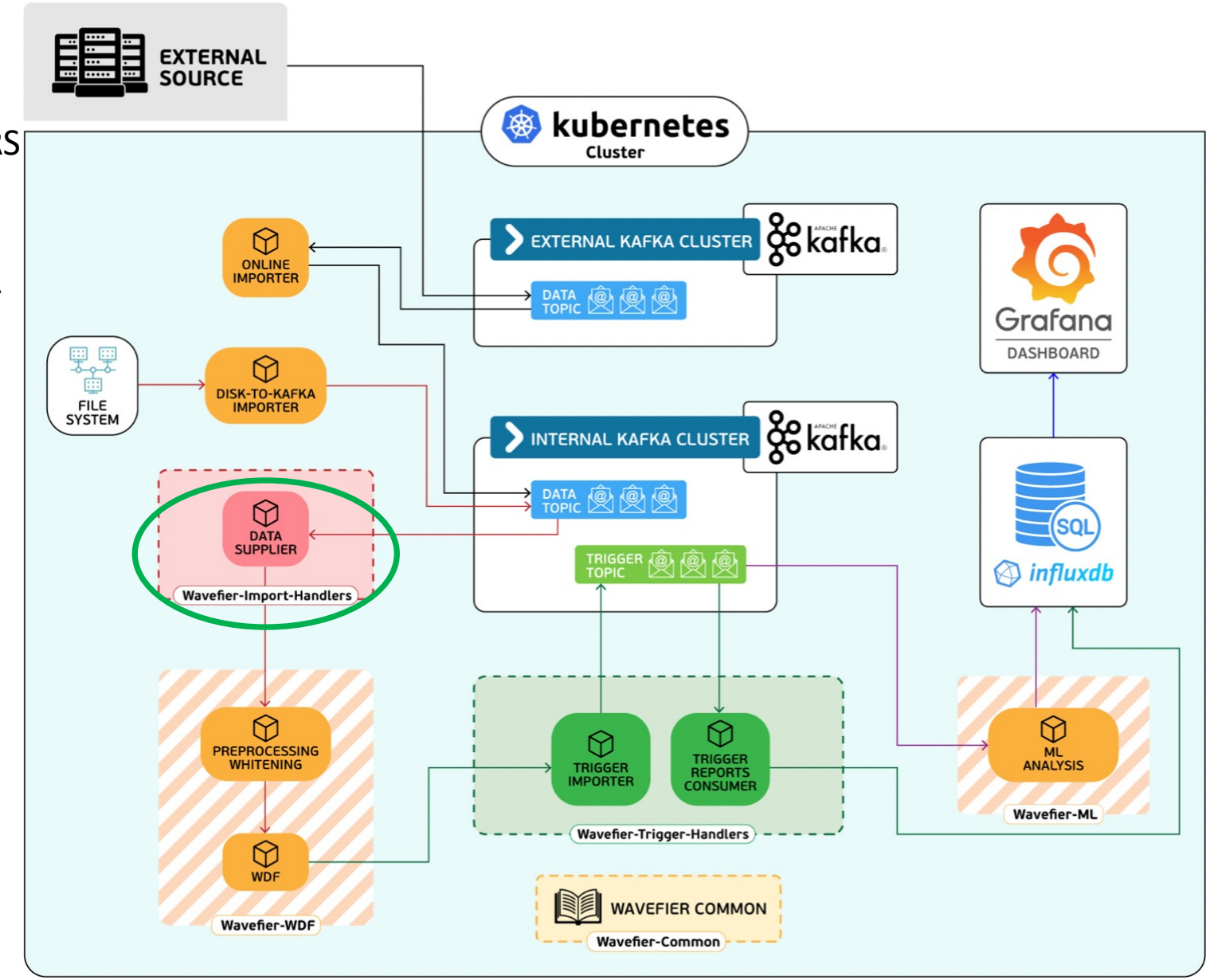
WAVEFIER-IMPORT-HANDLERS

Library to retrieve the files from topics in internal KAFKA cluster.



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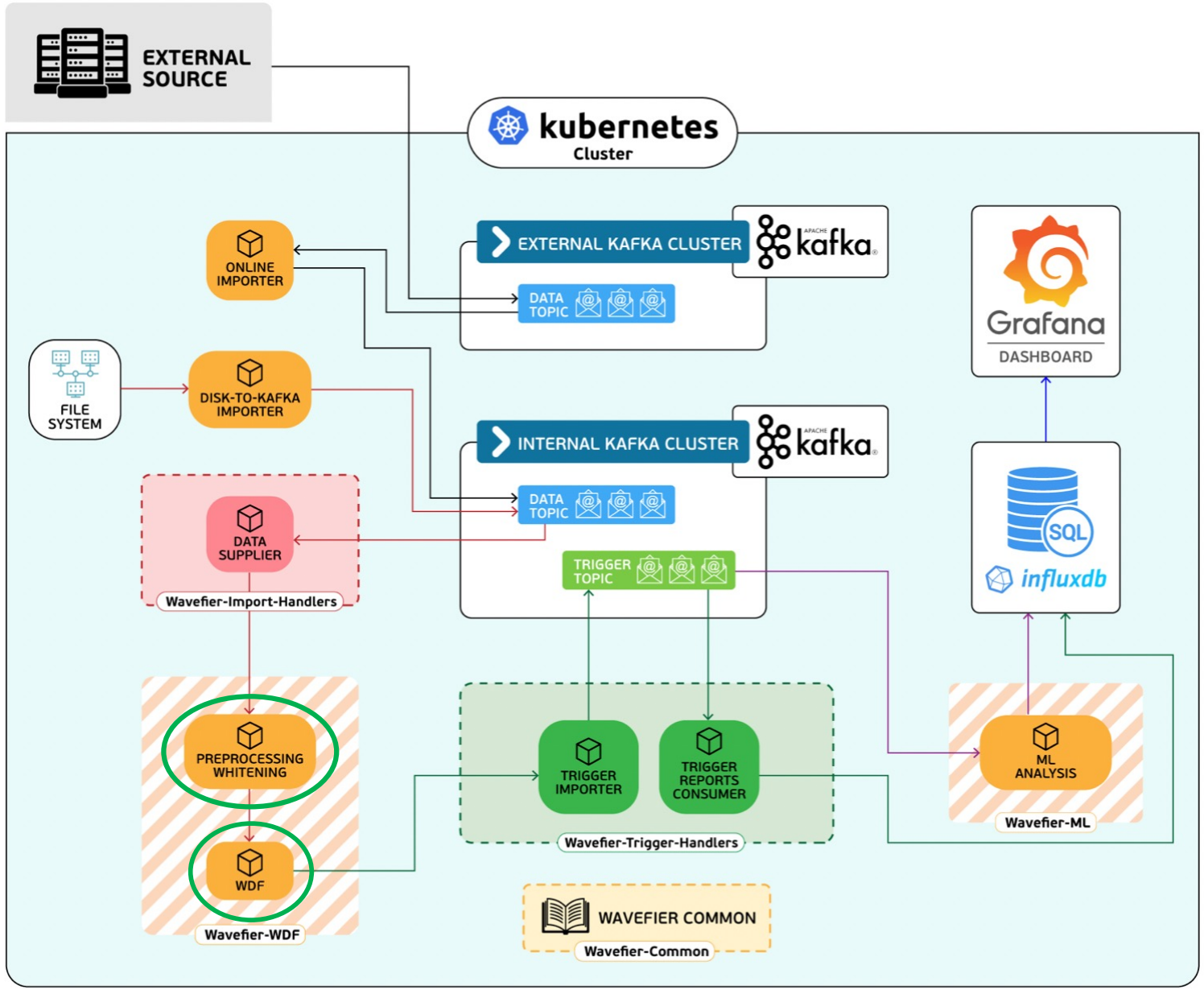
WAVEFIER PREPROCESSING WHITENING (*GW specific!)*

Continuously computes the whitening parameters for GW data and sends them to internal KAFKA cluster.



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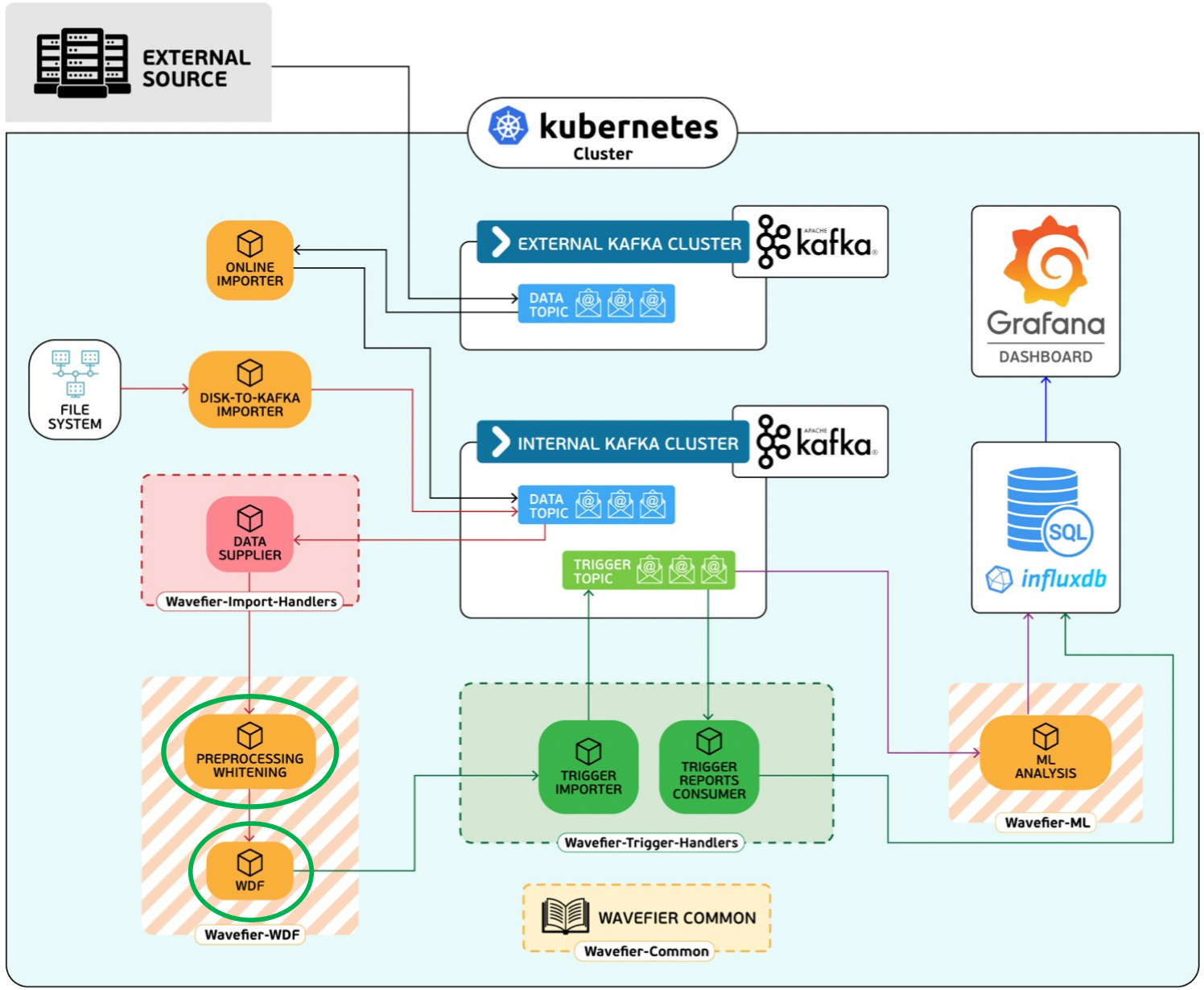
WAVEFIER-WDF (*GW specific!)*

Grabs updated whitening parameters and raw data, whitens GW data, searches for transient signals with a wavelet-based method and estimates relevant parameters of the detected signals.



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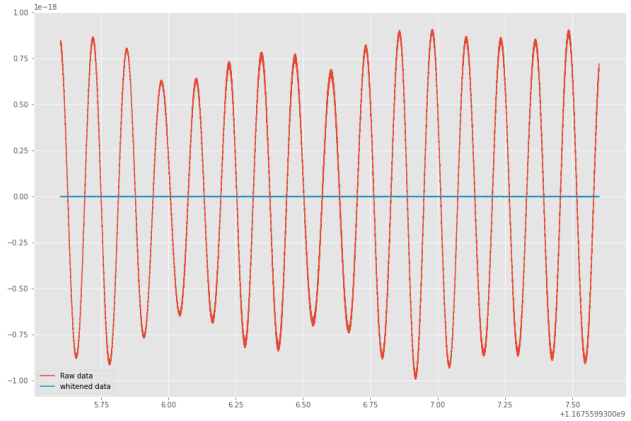
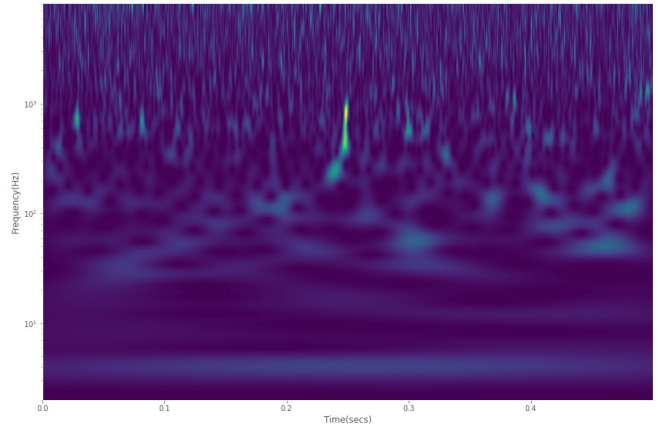
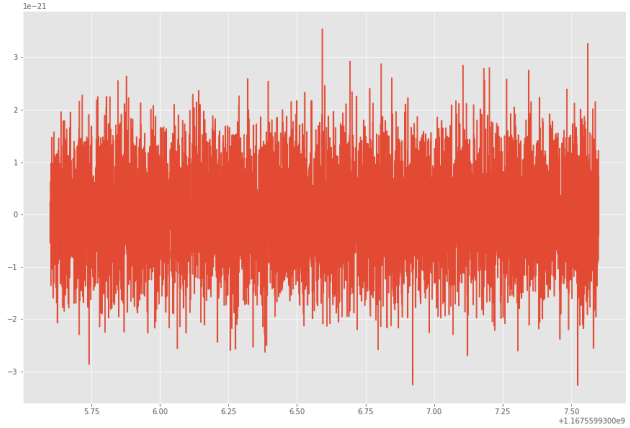
WDF (*GW specific!)*

- Data Preprocessing (whitening, downsampling)
- Trigger Generation
- *Source Parameter Estimation*
- *Signal Reconstruction*







GW170104

PUBLICATIONS THAT USE WDF (incomplete list):

1. J. Powell, D. Trifirò, E. Cuoco, I.S. Heng and Marco Cavaglià 2015, Class. Quantum Grav.
2.J. Powell, A. Torres-Forné, R. Lynch, D. Trifirò, E. Cuoco, M. Cavaglià, I.S. Heng and J.A. Font 2017, Class. Quantum Grav. **34** 034002
3. M. Razzano, E. Cuoco 2018, Class. Quantum Grav.
4. A. Iess, E. Cuoco, F. Morawski, J. Powell, 2020, Mach. Learn. Sci. Techno

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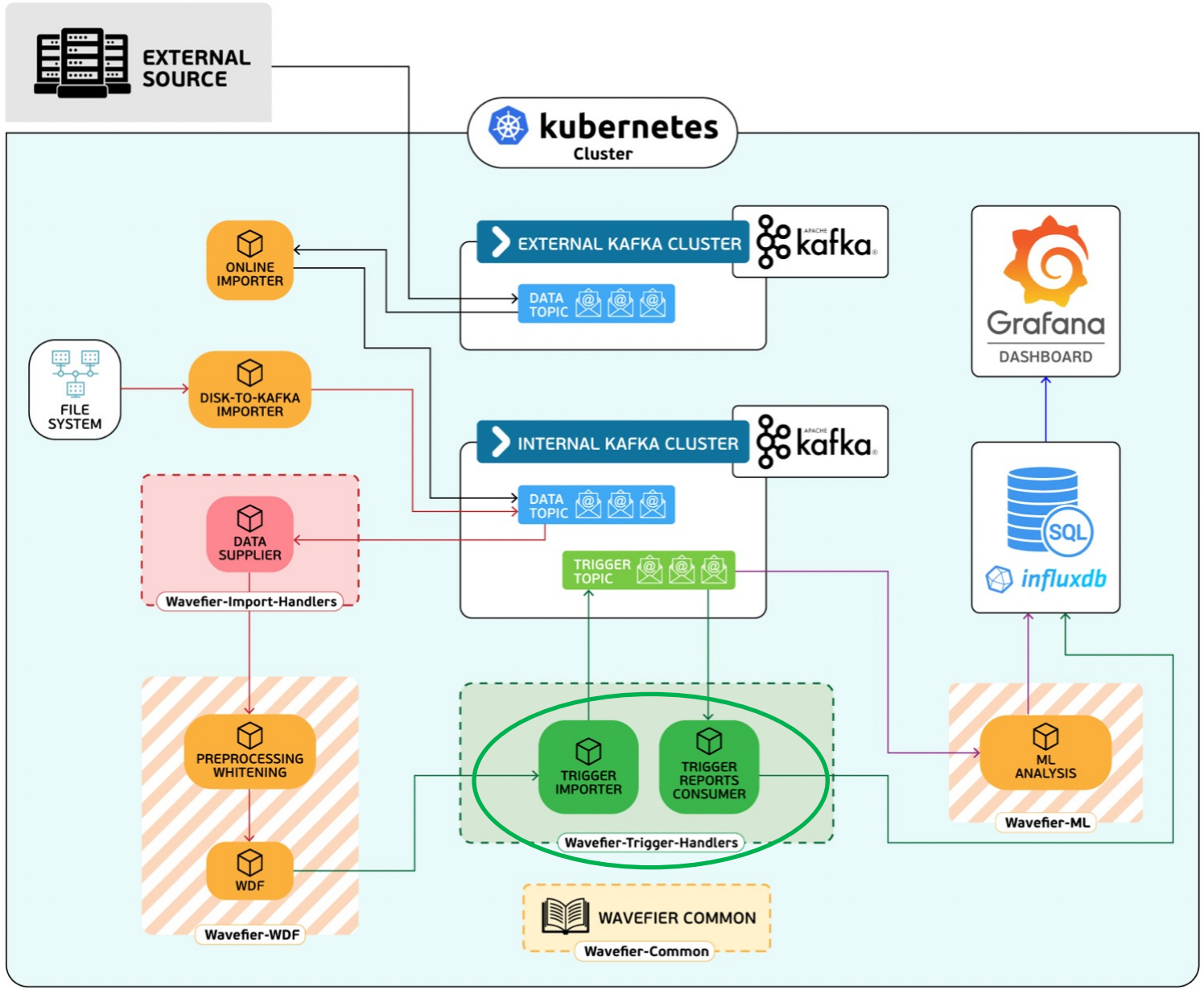
WAVEFIER
TRIGGER-HANDLERS

Contains all the code used to send and retreive the triggers and related information in the WAVEFIER framework.



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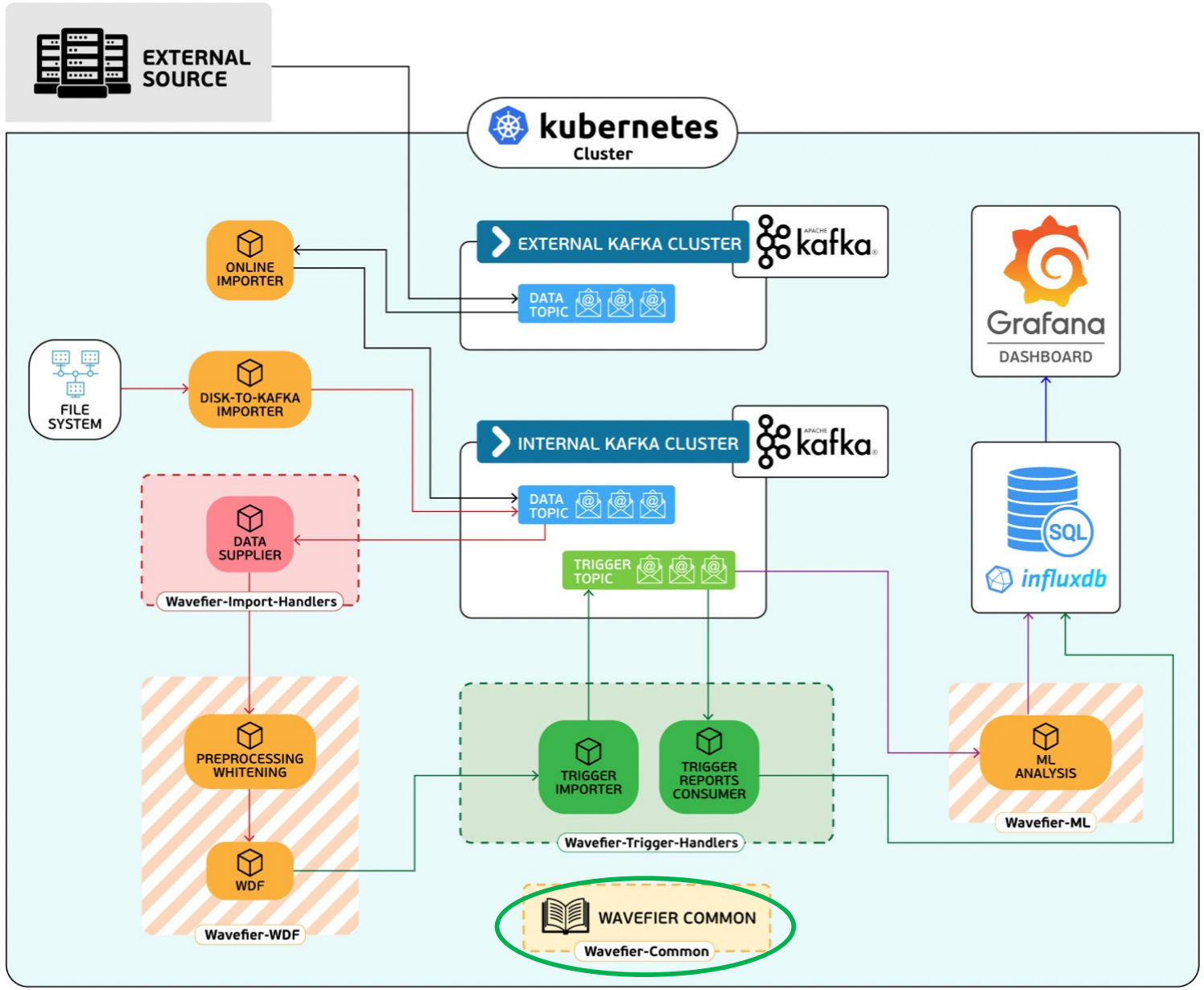
WAVEFIER COMMON

Contain all the common code used by different modules of the WAVEFIER project.



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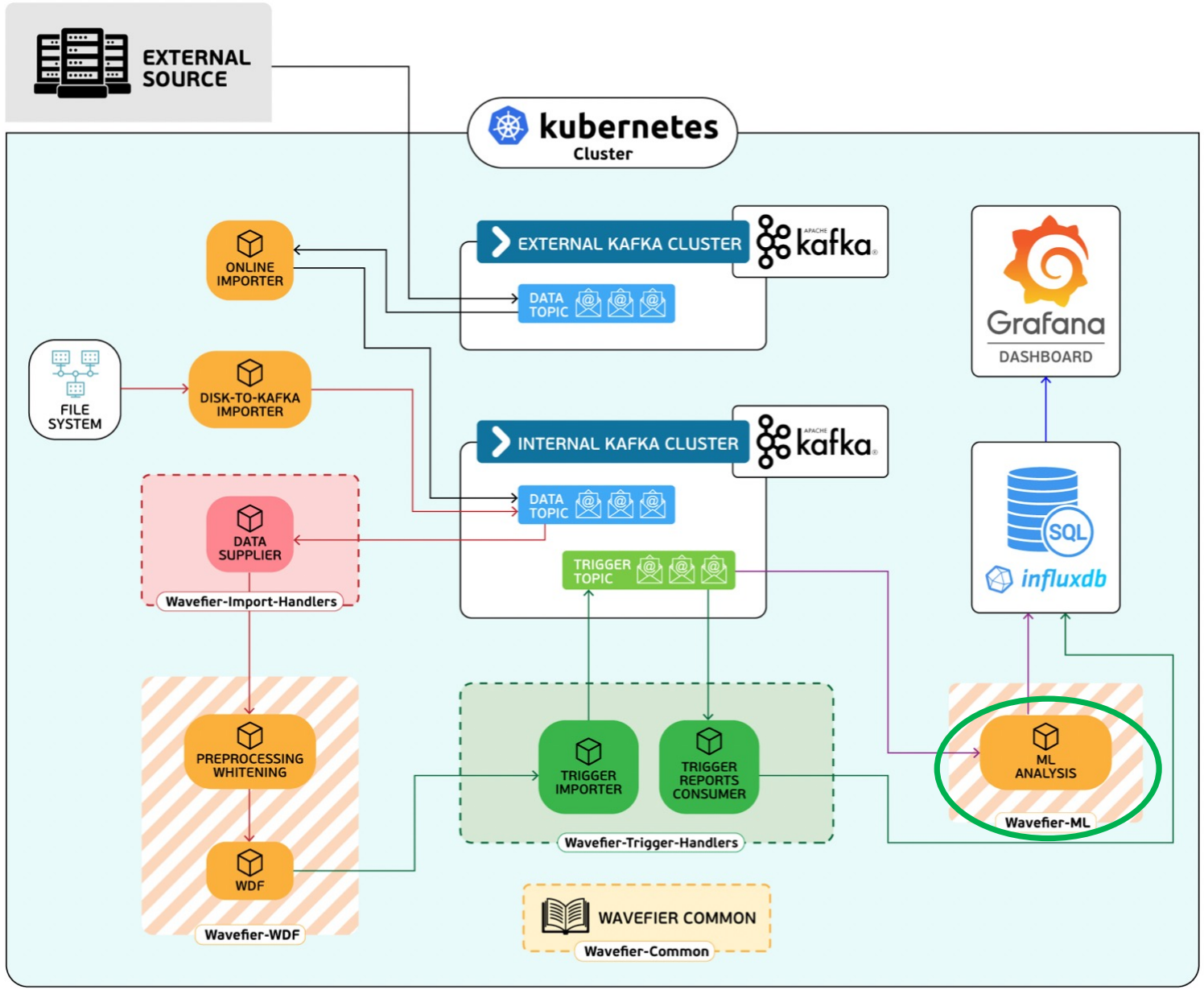
WAVEFIER ML

Responsible for the application of Machine Learning algorithms on the list of triggers generated by WAVEFIER WDF or similar consumers.



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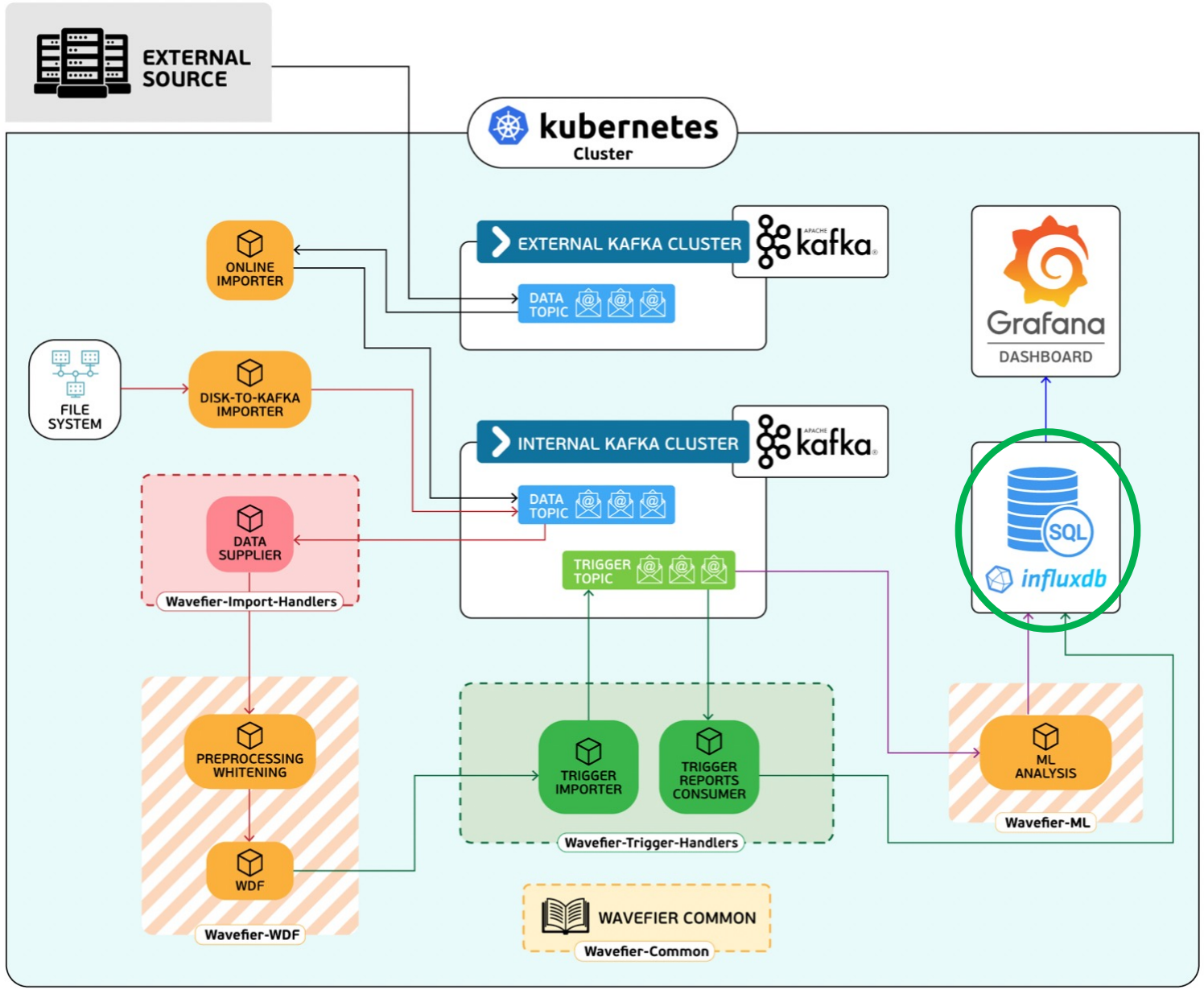
INFLUXDB

Database for storage of the triggers produced by WDF.

- Open-source, suited for timeseries analysis.
- has SQL-like query language for interacting with it.



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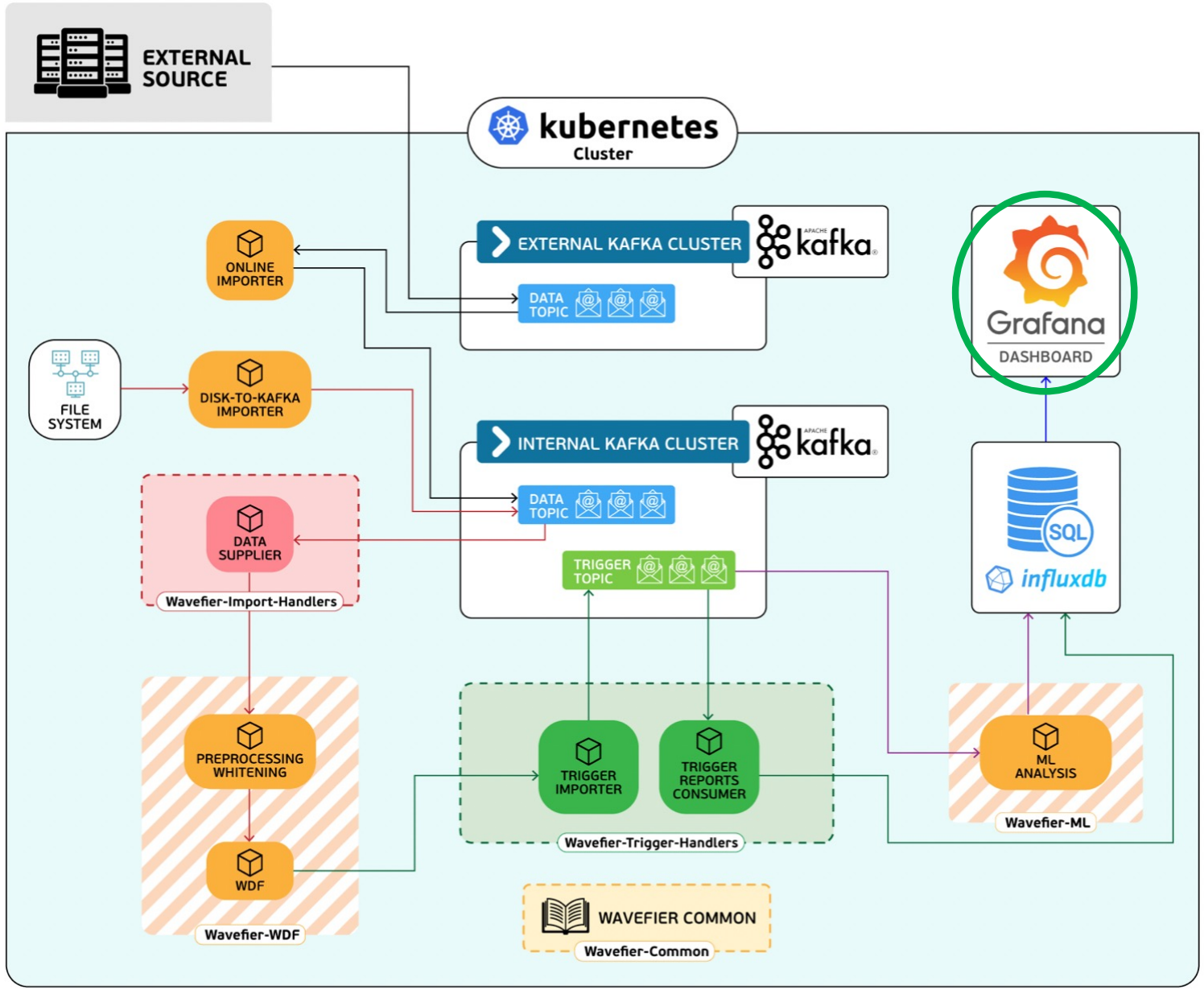
GRAFANA DASHBOARD

Provides interactive web visualization of trigger data.

- Native support for *influxDB.*



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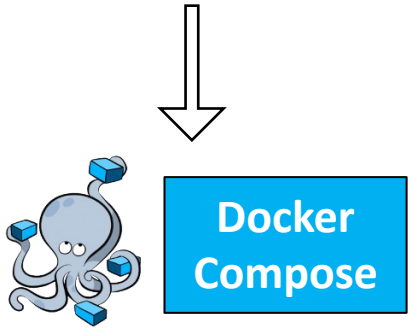
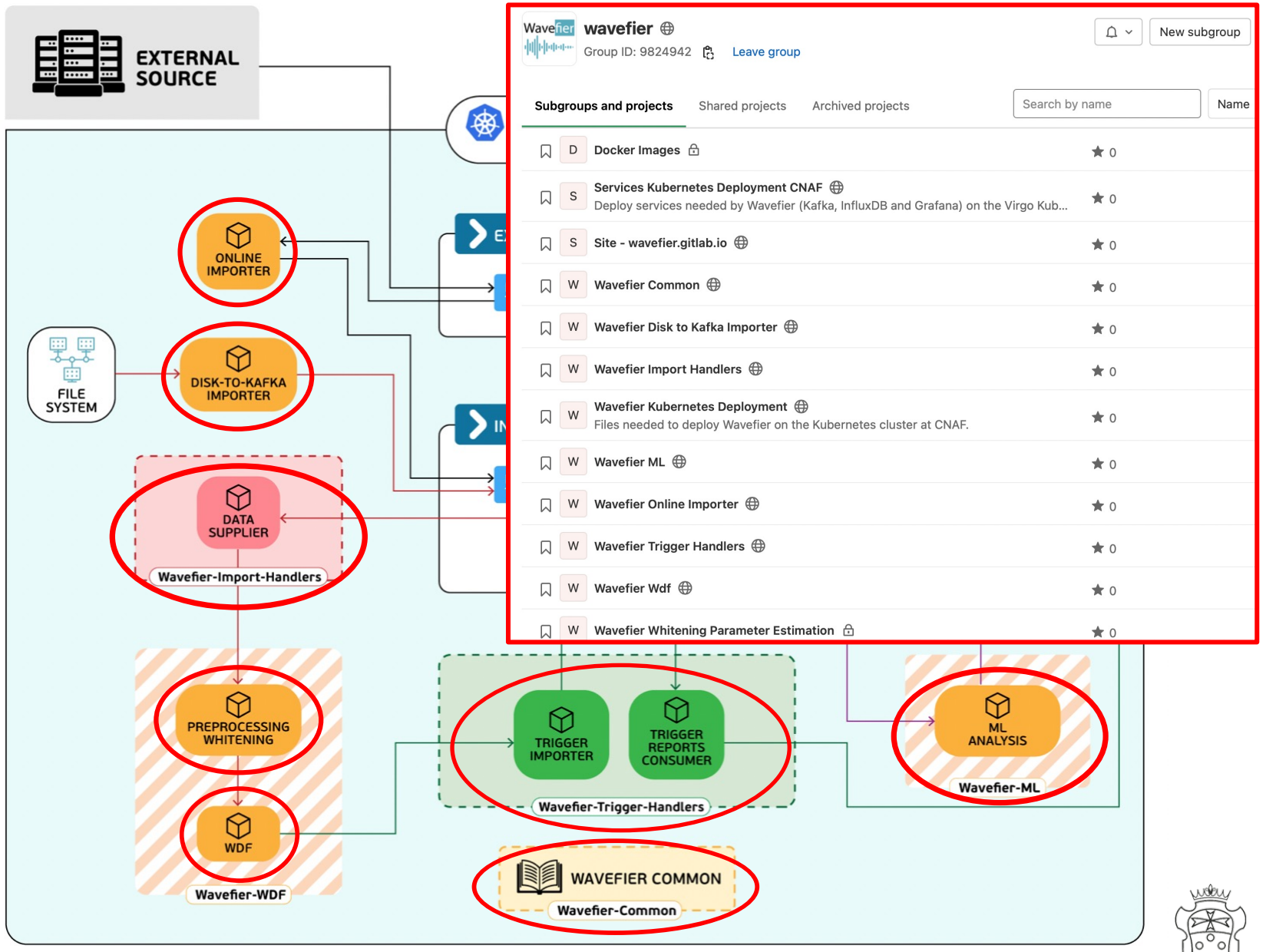
WAVEFIER's structure is composed of modules:

- Dedicated gitlab project with a repository for each module.
- Continuous integration to build docker images



portability!



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WAVEFIER: DOCUMENTATION

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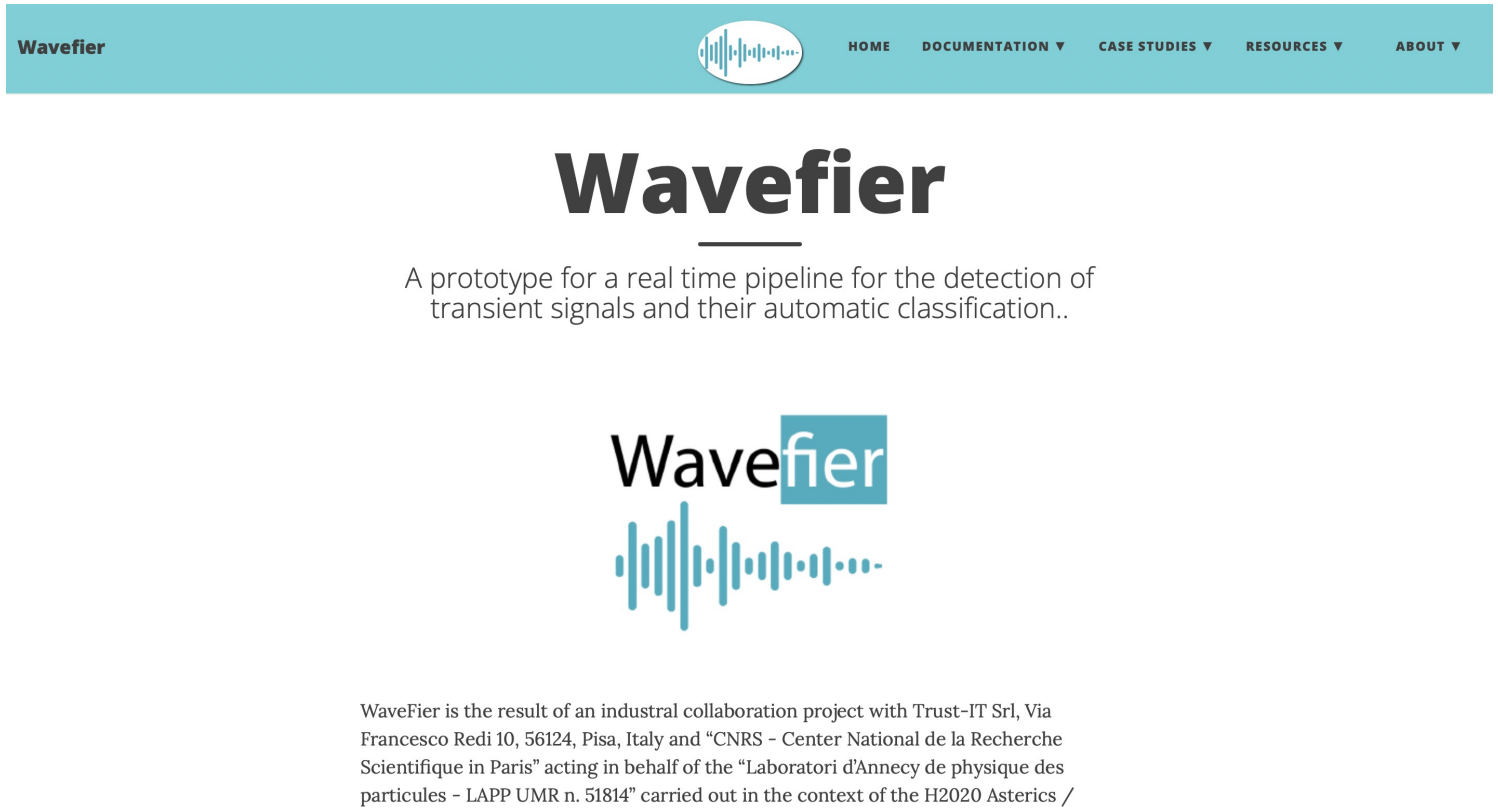
DOCUMENTATION

Currently being updated, available at:

https://wavefier.gitlab.io

Sphinx ReadTheDocs API documentation automatically generated at pipeline continuous integration for each component module.



WAVEFIER SCIENCE CASE: ESCAPE DATA LAKE

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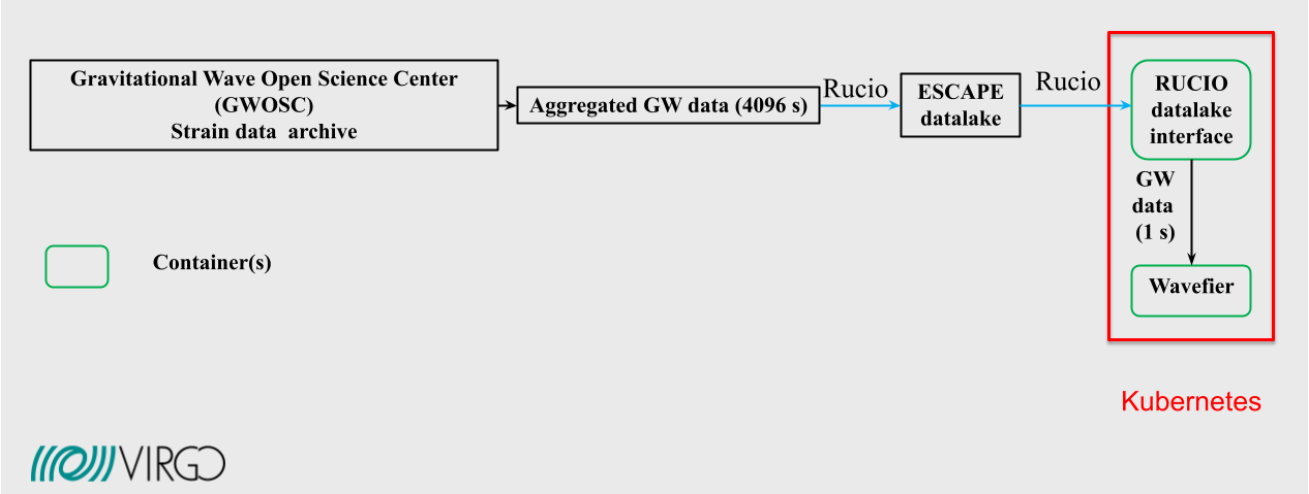

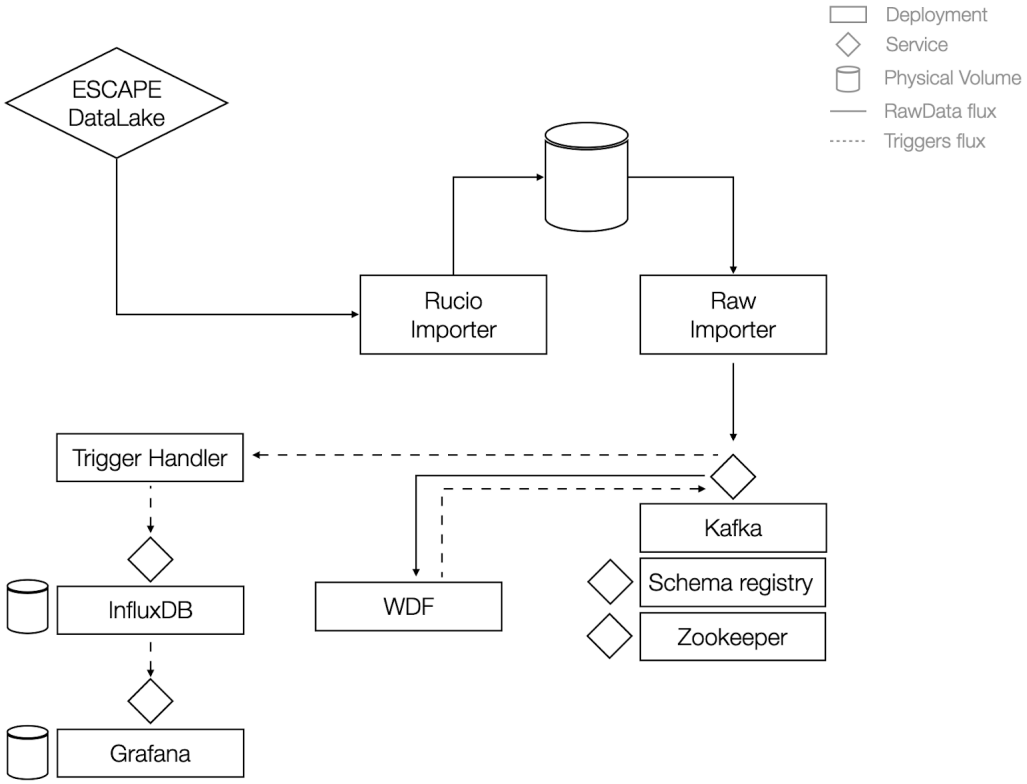

- Successfully tested attaching to ESCAPE data lake with Gravitational Wave Open Science Center (GWOSC) data.
- GW specific implementation at CNAF cloud (region Tier1) on shared Virgo Kubernetes cluster.
- Currently testing on O3 science data replay.

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WAVEFIER: ACTION ITEMS

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Gravitational Wave

VIRGO

- Test on O3 replay with continuous whitening

GRB

cta cherenkov telescope array

Neutrino

KM3NeT

UPDATE:

- Agreed with KM3Net and CTA counterparts to generate a common simulated multi-messenger dataset after summer.
- Start writing importer for associated data format when available.

WAVEFIER: UPDATES

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UPDATES WAVEFIER

- Currently testing on LIGO/Virgo O3 science data replay at CNAF.
- Testing implementation on **three detector data** via Kafka (with S.Vallero, E.Marzini).

UPDATES WDF

- Completed **refactoring of WDF** (Wavelet Detection Filter) library, for analysis of time series data (in our case, gravitational wave data). New version on Gitlab, new docker available.

UPDATES VRE ON-BOARDING PROCEDURE

- Obtained IT ESCAPE services accounts (IAM, rocket chat)
- Obtained, imported and linked x.509 certificate to IAM account.
- Installed docker version of Rucio client environment.
- Created scope “Virgo_INFN_Wavefier” and added sample open datasets from O3b science run at GWOSC (HDF5 format)
- Successfully searched for and tested importing through DLaaS.
- **NEXT (ongoing)**: add WDF part of Wavefier to show example of analysis on sample dataset.